The existing clouds will be furrowed obliquely, and the vortical stratum will be cut up into diamond-shaped spaces, determined by the intersection of the old and new vortex-axes. This would explain the patchwork arrangement commonly observed in mackerel sky. May not the lengths of the patches give a measure of the rate of veering of one of the currents ?—Jan. 4, 1884.]

The above account of the formation of ripple-marks shows it to be due to a complex arrangement of vortices. The difficulty of observation is considerable, and perhaps some of the conclusions may require modification. I hope that other experimenters may be induced to examine the question.

Lord Rayleigh has shown me a mathematical paper, as yet unpublished, in which he has considered the formation of aërial vortices over a vibrating plate. It seems possible that an application might be made of similar modes of approximation to the question of water oscillating over a corrugated bottom. Even a very rough solution would probably throw much light on the exact changes which the ripple-making vortices undergo, and any guidance from theory would much facilitate observation.

"On the Atomic Weight of Titanium." By T. E. Thorpe, F.R.S. Received November 7, 1883.

The stoïchiometrical quantities which we ordinarily term atomic weights are not only the fundamental constants of chemical calculations; their relations as mere numbers are of the highest significance in connexion with our conceptions concerning the essential nature of matter.

The recent publications of Becker and Clarke in America, and of Lothar Meyer and Seubert in Germany, have served to demonstrate on how slight an experimental basis a large number—the greater proportion, it must be confessed—of the accepted values of these constants really depend.

A notable instance of this fact is seen in the case of titanium. The atomic weight of this element was determined by Rose in 1829, and by Pierre in 1847 with the following results :—

$$
\begin{array}{ll}
\text{Rose.} \dots \dots \dots & 48 \cdot 13 \text{ and } 49 \cdot 58, \\
\text{Pierre} \dots \dots \dots & 50 \cdot 25.
\end{array}
$$

The commonly accepted value of titanium is that founded upon the experiments of Pierre; the atomic weight adopted by Mendelejeff in the series based upon his periodic law is 48, a number which finds

some experimental support from the observations of Rose. The direct evidence in favour of either value is, however, very slight, and a critical examination of the observations affords no ground for assuming that Rose's value is nearer the truth than that of Pierre. It is probable that the value 48 has been adopted in one or two modern text-books, mainly because it agrees best with the requirements of the periodic law.

I have attempted to deduce the atomic weight of titanium from observations made with the tetrachloride, the tetrabromide, and the dioxide. The present communication contains the results furnished by the analysis of the chloride. The work with this body affords three independent values for Ti based on the ratios—

$$\text{I.} \dots \dots \quad TiCl_4 : 4Ag$$
$$\text{II.} \dots \dots \quad TiCl_4 : 4AgCl$$
$$\text{III.} \dots \dots \quad TiCl_4 : TiO_2$$

Series I.—$TiCl_4 : 4Ag$.

Weighed quantities of the tetrachloride were decomposed by water in closed vessels, and the chlorine precipitated by silver after the method of Gay-Lussac as modified by Stas—

	Chloride taken.		Silver employed.		Ti (H = 1).
I.	2·43275	. . . .	5·52797	. . . .	48·06
II.	5·42332	. . . .	12·32260	. . . .	48·07
III.	3·59601	. . . .	8·17461	. . . .	47·99
IV.	3·31222	. . . .	7·52721	. . . .	48·05
V.	4·20093	. . . .	9·54679	. . . .	48·05
VI.	5·68888	. . . .	12·92686	. . . .	48·06
VII.	5·65346	. . . .	12·85490	. . . .	47·95
VIII.	4·08247	. . . .	9·28305	. . . .	47·94
	34·39004		78·16399		48·021

Series II.—$TiCl_4 : 4AgCl$.

Weighed portions of the tetrachloride after decomposition with water were treated with excess of silver nitrate, and the silver chloride separated by reverse filtration and weighed—

	Chloride taken.		Silver chloride.		Ti (H = 1).
IX.	3·31222	. . . .	10·00235	. . . .	47·99
X.	4·20093	. . . .	12·68762	. . . .	47·98
XI.	5·68888	. . . .	17·17842	. . . .	48·00
XII.	5·65346	. . . .	17·06703	. . . .	48·06
XIII.	4·08247	. . . .	12·32442	. . . .	48·06
	22·93796		69·25983		48·018

The total amount of the silver chloride thus obtained was 69·25983 grms. : it was formed from 53·13881 grms. of silver added in the preceding series. The weight of the silver chloride thus obtained from a known weight of silver and of titanium tetrachloride, not only affords an additional value for Ti, but it also serves as a rigorous check on the accuracy of the work, for if the ratio of Ag to AgCl is found to be the same as that obtained by the direct union of chlorine and silver, it at once disposes of the possibility of error due to the co-precipitation of titanic acid, and is a guarantee of the purity of the silver employed—

Now	$52·13881 : 69·25983 = Ag : AgCl = 1 : 1·3284.$

Stas found from seven experiments in which, in the aggregate, 969·3548 grms. of silver were found to give 1287·7420 grms. of silver chloride, that—

$$Ag : AgCl = 1 : 1·32845.$$

The two ratios, it will be seen, are almost identical.

Series III.—$TiCl_4 : TiO_2$.

The tetrachloride was decomposed by water, and the solution evaporated to dryness and strongly heated.

	Chloride taken.		Titanic oxide.		Ti ($H = 1$).
XIV	6·23398	....	2·62825	....	47·93
XV	8·96938	....	3·78335	....	48·00
XVI	10·19853	....	4·30128	....	47·95
XVII	6·56894	....	2·77011	....	47·96
XVIII	8·99981	....	3·79575	....	47·98
XIX	8·32885	....	3·51158	....	47·94
	49·29948		20·79032		47·970

All the experiments which were made, either for the estimation of the chlorine or the titanic oxide, are given with the exception of two ; one of these was made upon a small quantity of material, and was considered as merely preliminary ; the other miscarried and was not persevered with.

In order to enable an opinion to be formed as to the agreement among the several observations, I have calculated the value of Ti afforded by each experiment. But probably the most accurate values for the atomic weight would be deduced from the aggregate weights of the tetrachloride, silver, silver chloride, and titanic oxide, respectively. Inasmuch as it may be presumed that the employment of large quantities of material would tend to increase the accuracy of the result, by calculating the final values from the aggregate weights

instead of merely taking the means of the several observations, the influence of the larger quantities is directly felt.

Assuming with Lothar Meyer and Seubert that the most probable ratios of Ag, Cl, O, and H, are as follows—

$$Ag = 6 \cdot 7456$$
$$Cl = 2 \cdot 21586$$
$$O = 1$$
$$H = 0 \cdot 06265$$

the various experiments afford the following values for Ti :—

I........ $TiCl_4 : 4Ag\ \ = 34 \cdot 39004 : 78 \cdot 16399$
$\ = 1 \cdot 75989 : 4$
$\ \ \ \ \ \ \ \ \ TiCl_4 : O\ \ \ = 11 \cdot 8715\ \ : 1$
$\ \ \ \ \ \ \ \ \ Ti\ \ \ : O\ \ \ = 3 \cdot 0081\ \ : 1$
$\ \ \ \ \ \ \ \ \ Ti\ \ \ : H\ \ \ = 48 \cdot 014\ \ \ : 1$

II........ $TiCl_4 : 4AgCl = 22 \cdot 93796 : 69 \cdot 25983$
$\ = 1 \cdot 32475 : 4$
$\ \ \ \ \ \ \ \ \ TiCl_4 : O\ \ \ = 11 \cdot 8716\ \ : 1$
$\ \ \ \ \ \ \ \ \ Ti\ \ \ : O\ \ \ = 3 \cdot 0082\ \ : 1$
$\ \ \ \ \ \ \ \ \ Ti\ \ \ : H\ \ \ = 48 \cdot 016\ \ \ : 1$

III........ $TiCl_4 : TiO_2\ \ = 49 \cdot 29948 : 20 \cdot 79032$
$\ = 2 \cdot 37124 : 1$
$\ \ \ \ \ \ \ \ \ Ti\ \ \ : O\ \ \ = 3 \cdot 0053\ \ : 1$
$\ \ \ \ \ \ \ \ \ Ti\ \ \ : H\ \ \ = 47 \cdot 969\ \ \ : 1$

On the assumption that these values have equal weight, the final value becomes—

I.......... $\ \ 48 \cdot 014$
II.......... $\ \ 48 \cdot 016$
III.......... $\ \ 47 \cdot 969$

$$Ti = 48 \cdot 000$$

It would appear, therefore, from these observations, that titanium must be added to the increasing list of the elements whose atomic weights are simple multiples of that of hydrogen.

In these observations, which have occupied me many months, I have sought to eliminate such sources of error as were known to me. It is of course possible, in spite of the agreement between the several values, that the results may be affected by undetected and constant errors. Experience warns us that no determination of atomic weight, however well the individual observations may agree among themselves, can be considered wholly satisfactory if it depends upon a single reaction or is referred to a single relation. It is for this

reason that I have sought to extend my observations to other compounds of titanium, and to vary the nature of the reactions involved in the chemical process. Unfortunately it is found that comparatively few bodies containing titanium lend themselves to the purpose of atomic weight determination. I am, however, making observations with the tetrabromide, which, in some respects, is to be preferred to the tetrachloride, and the results furnished by its analysis will be given in a second communication, which will also contain details respecting the preparation of the substances used, the methods of weighing, the processes of manipulation, effect of errors, &c. With reference to the tetrabromide, I may here say that I find it can be very easily made by the action of hydrobromic acid gas upon the chloride, and that this proves to be a more convenient method of preparation than that by which it was first obtained by Duppa.

III. "On the Life History of the Dock Æcidium (*Æcidium rumicis*, Schlecth)." By CHARLES B. PLOWRIGHT. Communicated by W. THISELTON DYER, M.A., F.R.S. Received November 10, 1883.

This Æcidium, which is common in this country upon *Rumex hydrolapathum*, Huds., *obtusifolius*, Linn., *crispus*, Linn., and *conglomeratus*, Murray, was regarded by Fuckel* and Cooke† as being a condition of *Uromyces rumicis* (Schum.), is now stated by Winter‡ in his last work to be a condition of *Puccinia magnusiana*. During the present year I have conducted a series of cultures, in which the life history of this fungus has been carefully, if not laboriously, worked out, from which it appears that *Æcidium rumicis* bears the same relationship to *Puccinia phragmitis* (Schum.) (= *P. arundinacea*, D.C.) as *Æcidium berberidis*, Gmel., bears to *Puccinia graminis*, Perss.

History of the Subject.—Winter, in 1875,§ showed that those botanists who had associated this Æcidium with the *Uromyces rumicis*, simply because these two fungi occurred upon the same host plant, were wrong, and that the fungus in question was the æcidiospore of *Puccinia phragmitis*. Stahl, in 1876, repeated Winter's experiment, and confirmed it. Now it happens that there are two *Pucciniæ* common upon *Phragmitis communis*, the *P. phragmitis* (Schum.), and *P. magnusiana*, Körn.‖ In March, 1877, Schröter¶ placed the spores

* Fuckel, "Symbol. Mycol.," p. 64.

† Cooke, "British Uromyces," Grevillea, VII, p. 136.

‡ Winter, "Rabenhorst's Kryptogamen-Flora," 1881, p. 222.

§ Winter, "Hedwigia," 1875, vol. xiv, pp. 113–115.

‖ Körnicke, "Hedwigia," 1876, vol. xv, p. 179.

¶ Schröter Cohn, "Beitrage zur Biologie der Pflanzen," vol. iii, Heft I, pp. 65–66.